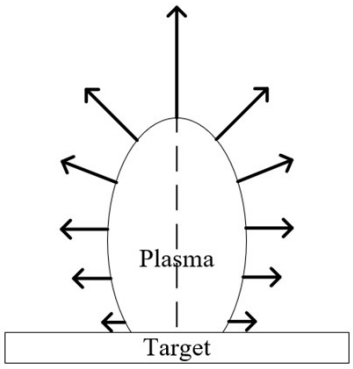

Fig. S1 Spatial distribution of plasma.

Influence of open smooth triangular cavity on self-absorption effect

The interior temperature of the plasma is higher than its exterior temperature. When the emission lines generated from the interior parts of plasma pass through the exterior parts, they are absorbed by low-temperature particles, resulting in self-absorption, which reduces the intensity of the emission lines and even causes self-reversal. We evaluate spectral self-absorption effects with and without open smooth triangular cavity. The formula of self-absorption coefficient (SA) is shown in Eq (S1) [S1]. The value of SA is from 0 to 1. The lower the SA value, the stronger the self-absorption.

$$SA = \frac{I(\lambda)}{I_0(\lambda)} = \frac{1 - e^{-k(\lambda)L}}{K(\lambda)L} \tag{S1}$$

where *I* is the measured spectral intensity, *I0* is the spectral intensity of an ideal optically thin plasma (the theoretical intensity without self-absorption), λ is wavelength of spectral line, L is the length of absorption path and K(λ)L is the optical thickness.

$$K(\lambda)l = \alpha C \tag{S2}$$

$$SA = \frac{1 - e^{-\alpha C}}{\alpha C} \tag{S3}$$

$$I(C) = A\left(1 - e^{-\alpha C}\right) + I_b \tag{S4}$$

K(λ)L is shown in Eq (S2) [S2], where α is a proportionality coefficient and C is the element content. Then Eq (S1) takes the form of Eq (S3). α can be obtained by calibration curve fitted by exponential function, as shown in Eq (S4) [S3], where A and Ib are constants. The larger the α, the smaller the SA, and the stronger the self-absorption.

The self-absorption effect of Fe lines in standard stainless steel is evaluated. The stainless steel are shown in Table 4 of the paper. Standard samples are numbered from 1 to 6. For comparing the self-absorption effect with and without cavity, the spectral line Fe I 388.6142 nm of a standard sample is shown in Fig. S2. The lower and upper energy level of Fe I 388.6142 nm is 0.0516 eV and 3.241 eV, respectively. The probability of resonance is very high. Thus, the line can be used to evaluate the self-absorption effect. We can see that the open smooth triangular cavity enhances the spectral intensity. However, the influence of the cavity on self-absorption cannot be determined by Fig. S2.

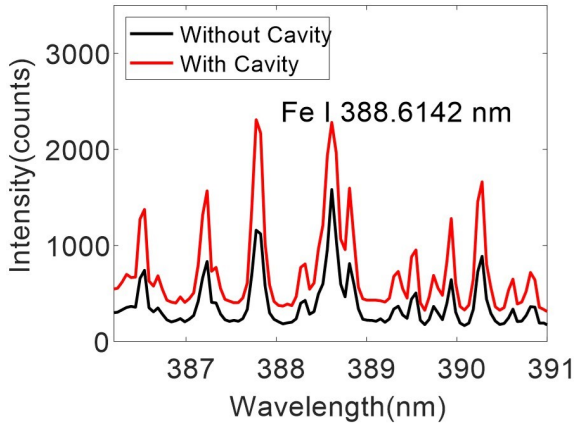

Fig. S2 The spectral intensity of Fe I 388.6142 with and without open smooth triangular cavity. The red and black lines represent spectra with and without cavities, respectively.

The self-absorption calibration curves of Fe I 388.6142 nm is fitted by Eq (S4). Fig. S3 (a) and (b) show the results without and with cavities, respectively. The fitting coefficient R^2 with cavity is greater than that without cavity. When the Fe content is greater than 71%, the spectral intensity of standard samples No.5 and No.6 without cavity shows a slight decrease compared with No.4 due to self-absorption. But this decreasing trend for that of with cavity is improved. The α values with and without cavities are 0.859 and 0.918, respectively. Their difference is 0.059, which demonstrates self-absorption effects with and without cavity are almost close. The results show that the open smooth triangular cavity can slightly improve the self-absorption effect of Fe.

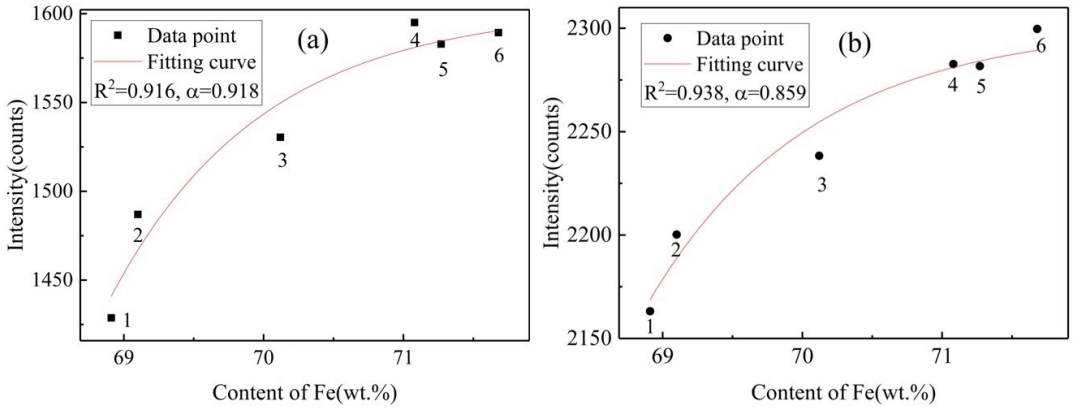

Fig. S3 Self-absorption calibration curves. Figures (a) and (b) show the results without and with cavities, respectively. The digits in the figure are the standard samples' number.

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